

## Our Approach

Highly reactive nanocrystalline metal oxide sorbents will be integrated with textile matrices to produce laminates that are suitable in the manufacturing of textiles for protection against toxic industrial chemicals (TICs) and chemical warfare agents (CWAs).



## Specific Objectives

- Lightweight
- Air-permeable
- Comfortable
- Effective against liquids and vapors
- Engineered formulations for wide spectrum adsorption
- Destructive adsorption
- Increased and instantaneous protection
- Enable safe, effective, and comfortable operation by the wearer

## Available Technology

- Air-permeable materials
- Semi-permeable materials
- Impermeable materials
- Selectively permeable materials

## Key Features of Available Air-permeable Materials

- Permeable to air, liquids, vapors and aerosols
- Consist of woven shell fabric
- A layer of activated carbon impregnated foam or carbon loaded non-woven felt
- Liner fabric

## Limitations of Carbons

- Partial protection by physical entrapment of toxins
- Preferential adsorption of water
- Increased temperature results in off-gassing of adsorbed toxins
- No effect on acid or alkaline gases

## Uniqueness of NanoActive® Materials

### Extraordinary Chemical Reactivity

- High porosity
- Small crystallite sizes
- Large surface area
- Unique morphologies

### Proven Safe by Independent Testing

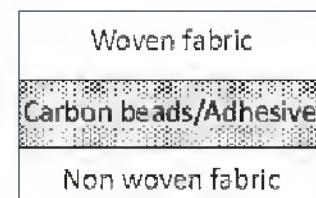
- Pulmonary
- Ocular
- Oral
- Skin sensitization and irritation



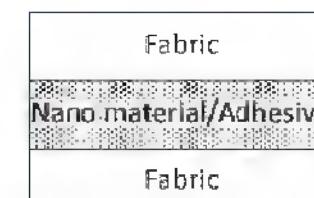
## Desired Improvements in Select Properties

Property	Carbon Bead Laminate	NanoScale Proposed Laminate
Total Weight ( $\text{g}/\text{m}^2$ )	402	350
Sorbent: Fabric Weight (g)	250:152	250:100
Air Permeability ( $\text{cm}^3/\text{cm}^2.\text{s}$ )	63	$\geq 63$

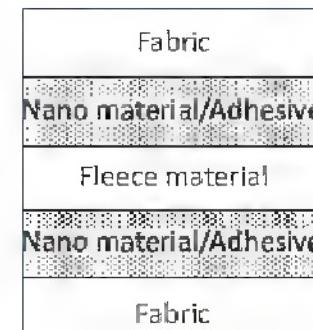
## Configurations of Compared Laminates



Carbon Bead Laminate



2 Layer Laminate-NS



3 Layer Laminate-NS

## Physical Characteristics and Permeation Data

Sample	Total Weight ( $\text{g}/\text{m}^2$ )	Sorbent: Fabric (g)	Air Perm ( $\text{cm}^3/\text{cm}^2.\text{s}$ )	Chemical Permeation			
				Cumulative Permeation 1 hr $\mu\text{g}/\text{cm}^2$	Maximum Permeation Rate $\mu\text{g}/\text{cm}^2/\text{min}$	2-CEES	DMMP
Carbon Bead Laminate	402	250:152	63	23	6.7	310	624
2 Layer Laminate	338	250:88	60	6.6	0.44	0	0.004
3 Layer Laminate	377	250:127	45	5.9	0.60	0	0

## Evidence for Destructive Adsorption

Sample	% Recovered		Sample	% Recovered	
	2-CEES	HEES		DMMP	MPA
Carbon Bead Laminate	92	0	Carbon Bead Laminate	85	Absent
2 Layer Laminate	1.4	18	2 Layer Laminate	24	Present
3 Layer Laminate	1	13	3 Layer Laminate	20	Present

## From Meritorious Material to Marketable Product



## Key Conclusions/Near Term Plans

- Improved granule immobilization with significantly reduced shedding
- Weight reduction at the fabric level for excellent chemical protection
- Concept was proven at the laminate manufacturing level
- Exploring markets related to emergency, medical, military and industrial apparel
- Exploring use in other areas such as various DOD and civilian products
- Refining to meet the demands of the 21<sup>st</sup> century